CLAIMS

1. A two-way communications device comprising:

an analog signal processor that includes a transducer, the analog signal processor receiving a reception signal and outputting a transmission signal; and

a digital signal processor (DSP) configured to measure operating characteristics of the analog signal processor and use the measured operating characteristics to filter reception signal echo from the transmission signal.

2. The device of claim 1 wherein the digital signal processor includes a filter coefficient calculator that generates filter coefficients that simulate the measured operating characteristics of the analog signal processor.

3. The device according to claim 2 wherein the digital signal processor includes a filter that applies the filter coefficients generated by the filter coefficient calculator to the reception signal to generate an output signal, the digital signal processor further including an adder that applies the filter output to the transmission signal.

4. The device according to claim 1 including switching functions that connect a test signal to the analog signal processor and measures the operating characteristics of the analog signal processor using the test signal.

5. The device according to claim 1 wherein the digital signal processor monitors the operating characteristics of the transducer while the transducer is located in an external ear canal.

6. The device according to claim 1 wherein the digital signal processor periodically measures the operating characteristics of the transducer while in operation and uses the periodic measurements to continuously adjust the filtering of the reception signal echo from the transmission signal.

7. The device according to claim 1 wherein the digital signal processor includes a voice operated exchanger (VOX) controlling attenuation of the reception signal and the transmission signal according to predetermined gain values.

8. The device according to claim 7 including:

a first analog to digital converter (A/D) converting the reception signal received by the VOX;

a first low pass filter filtering the A/D converted reception signal;

a first attenuator attenuating the reception signal; and

a power controller controlling attenuation of the reception signal by the attenuator according to the filtered A/D converted reception signal.

9. The device according to claim 8 including a second attenuator attenuating the transmission signal output from the analog signal processor according to the power controller.

10. The device according to claim 9 including a second low pass filter receiving the transmission signal from the analog signal processor and sending a filtered transmission signal to the second attenuator, the power controller controlling attenuation of the filtered transmission output signal according to a power level of the filtered transmission signal or power level of the filtered reception signal.

11. The device according to claim 7 wherein the digital signal processor further includes an echo canceller (EC) receiving the reception signal from the VOX and outputting the transmission signal with reception signal echo cancellation to the VOX.

12. The device according to claim 11 including:

a first analog to digital converter (A/D) operating between a reception terminal and the VOX;

a first digital to analog converter (D/A) operating between the reception signal output from the EC and the analog signal processor;

a second A/D converter operating between the transmission signal output from the analog signal processor and the EC; and

a second D/A converter operating between the transmission signal output from the VOX and a transmission terminal.

13. The device of claim 12 wherein the echo canceller includes:

a first buffer with an output coupled to both an input of the first D/A converter and an input of a first compensation filter;

a second buffer with an input coupled to an output of the second A/D converter, wherein the compensation filter is configured to simulate transmission characteristics along a signal path starting at the input of the first D/A converter, passing through the analog signal processor, passing through the second A/D converter, and ending at an output of the second buffer; and

an adder configured to subtract an output of the compensation filter from the output of the second buffer.

14. A device according to claim 13 including:

a first switch configured to selectively provide an input of the first buffer to either the voice-operated exchanger or a test signal generator;

a parameter calculator receiving the outputs of the first and second buffers and configured to set the parameters of the compensation filter by processing a signal from the second buffer and a test signal from the first buffer; and

a second switch configured to selectively provide an output of the adder to either the voice-operated exchanger or to a ground.

15. The device of claim 7 wherein the analog signal processor includes a four-sided bridge circuit having a first node coupled to the reception signal output from the digital signal processor and having a second node outputting the transmission signal to the digital signal processor.

16. The device according to claim 15 wherein the analog signal processor includes a first amplifier coupled between the first node and the reception signal

output from the EC and a second differential amplifier is coupled to the first and second nodes of the bridge circuit and outputs the transmission signal to the EC.

17. The device of claim 15 wherein the bridge circuit includes:

a first side having a first resistor coupled in series with a first capacitor and both coupled in parallel with the transducer;

a second side having a second resistor;

a third side having a third resistor connected in parallel with a second capacitor; and

a fourth side having a fourth resistor.

18. The device according to claim 7 wherein the analog signal processor includes a variable resistor having a first end coupled to the reception signal output from the digital signal processor and a second end coupled to the transmission signal output to the digital signal processor and a center tap coupled to the VOX, the center tap moved toward the first end or second end by the VOX according to a selected reception mode or selected transmission mode.

19. In a two-way communication device comprising a digital signal processor and an analog signal processor with a transducer that is designed to be inserted into an ear canal, a method comprising:

configuring a filter in the digital signal processor to simulate a signal path through the analog signal processor; and

subtracting an output of the filter from an output of the analog signal processor to substantially cancel an echo component present in the output of the analog signal processor.

20. The method of claim 19, wherein configuring the filter in the digital signal processor to simulate the signal path through the analog signal processor comprises:

generating a test signal;

propagating the test signal through the signal path while the transducer is placed in an external ear canal; and

setting parameters of the filter based on characteristics of the propagated test signal.

21. The method of claim 20, wherein generating the test signal comprises:

generating a test signal chosen from the group consisting of a digital signal that corresponds to any one of the following: an impulse, an actual voice during conversation, a natural voice, a reception sound, or a musical sound; a diffusion code signal, and a tone sweep signal.

22. The method of claim 19 including reconfiguring the filter after a predetermined amount of time to compensate for a variation of the acoustic conditions of the ear canal.

23. In a two-way communication device comprising a digital signal processor and an analog signal processor, the analog signal processor including a transducer that is designed to be inserted into an ear canal, a method comprising:

simulating a combined first and second signal path through the analog signal processor using a first filter located in the digital signal processor;

simulating the first signal path through the analog signal processor using a second filter located in the digital signal processor; and

subtracting an output of the first filter from an output of the analog signal processor to substantially cancel an echo component present in the output of the analog signal processor.

24. The method of claim 23 including:

placing the single transducer in an external ear canal;

generating a test signal;

propagating the test signal through the first and second signal paths; and

setting parameters of the first filter based on characteristics of the propagated test signal.

25. The method of claim 24 including:

propagating the test signal through the first signal path while an input to the second signal path is grounded;

propagating the test signal through the second signal path while an input to the first signal path is grounded; and

setting parameters of the second filter based on characteristics of the propagated test signal.

26. The method of claim 24 including generating a test signal chosen from the group consisting of a digital signal that corresponds to any one of the following: an impulse, an actual voice during conversation, a natural voice, a reception sound, or a musical sound; a diffusion code signal, and a tone sweep signal.

27. The method of claim 23 including reconfiguring the first filter and the second filter after a predetermined amount of time so that a variation of the acoustic conditions of the ear canal are adjusted for.

28. In a two-way communication device comprising a digital signal processor and an analog signal processor, the analog signal processor including a transducer that is designed to be inserted into an ear canal, the digital signal processor having a voice operated exchanger, a method comprising:

selectively switching between a reception mode and a transmission mode in response to a natural ebb and flow of conversation.

29. The method of claim 28, wherein selectively switching between the reception mode and the transmission mode comprises:

monitoring a reception signal from an input of the two-way communication device;

operating in the reception mode if the reception signal is determined to be present; and

operating in the transmission mode if the reception signal is determined to be absent.

30. The method of claim 28, wherein selectively switching between the reception mode and the transmission mode comprises:

monitoring a transmission signal from an output of the transducer;

operating in the transmission mode if the transmission signal is determined to be present; and

operating in the reception mode if the transmission signal is determined to be absent.

31. The method of claim 28, wherein selectively switching between the reception mode and the transmission mode comprises:

monitoring a reception signal from an input of the two-way communication device;

monitoring a transmission signal from an output of the transducer;

operating in the reception mode if only the reception signal is determined to be present;

operating in the transmission mode if only the transmission signal is determined to be present;

statistically selecting either the reception mode or the transmission mode if both the reception and the transmission signal or neither the reception signal nor the transmission signal are determined to be present.

32. The method of claim 28, wherein selectively switching between the reception mode and the transmission mode comprises:

calculating an average amplitude value over a predetermined time period from at least one signal chosen from the group consisting of a reception signal from an input of the two-terminal device and a transmission signal from an output of the transducer;

determining the presence or absence of the at least one signal by comparing a power level calculated with the average amplitude value to a predetermined threshold;

switching from transmission mode to reception mode by changing a gain of a first attenuator associated with the reception signal from a lower limit to an upper limit and changing a gain of a second attenuator associated with the transmission signal from the upper limit to the lower limit; and

switching from reception mode to transmission mode by changing the gain of the first attenuator from the upper limit to the lower limit and changing the gain of the second attenuator from the lower limit to the upper limit.

33. The method of claim 32, wherein switching from transmission mode to reception mode comprises:

gradually increasing the gain of the first attenuator from the lower limit towards the upper limit according to a predetermined gain transition curve, wherein the gain of the first attenuator becomes closer to the upper limit for every predetermined time interval that the reception mode is indicated; and

gradually decreasing the gain of the second attenuator from the upper limit towards the lower limit according to the predetermined gain transition curve, wherein the gain of the second attenuator becomes closer to the lower limit for every predetermined time interval that the reception mode is indicated.

34. The method of claim 33, wherein switching from recéption mode to transmission mode comprises:

gradually decreasing the gain of the first attenuator from the upper limit towards the lower limit according to the predetermined gain transition curve, wherein the gain of the first attenuator becomes closer to the lower limit for every predetermined time interval that the transmission mode is indicated; and

gradually increasing the gain of the second attenuator from the lower limit towards the upper limit according to the predetermined gain transition curve, wherein the gain of the second attenuator becomes closer to the upper limit for every predetermined time interval that the transmission mode is indicated.

35. The method of claim 34, wherein the predetermined gain transition curve is has a substantially S-shaped staircase profile, wherein the gain change per

unit decision is small near the upper and lower limit and large in an intermediate range between the upper and lower limits.

36. The method of claim 35, wherein the upper and lower limits are 1 and 0, respectively.

37. A two-way communications device comprising:

an analog signal processor that includes a piezoelectric transducer and a variable resistor having an intermediate tap, the piezoelectric transducer configured to convert vibrations into an electromotive force and to convert voltage into vibrations; and

a digital signal processor that includes an analog to digital (A/D) converter and a voice-operated exchanger, wherein the voice-operated exchanger monitors a reception signal via the A/D converter, determines the presence or absence of reception signals to determine a next potential operation mode as either a reception mode or a transmission mode, and controls the position of the intermediate tap according to the determined next potential operation mode.

38. A device according to claim 37 including:

a reception terminal coupled to a first end of the variable resistor via a first amplifier and a first analog attenuator, while a second end of the variable resistor is connected to a transmission terminal via a second amplifier and a second analog attenuator, wherein a position of the intermediate tap and a gain of the first and the second analog attenuators are controlled by digital signals from the voice-operated exchanger.

39. The device of claim 38, wherein:

the voice-operated exchanger comprises a first low-pass filter and a power-controller;

the reception signal is supplied to the power-controller after being processed by the first low-pass filter;

the power-controller is configured to average an amplitude of the reception signal over a predetermined time to determine a power of the reception signal, to compare the power with a predetermined threshold, and to determine the presence or absence of reception signals;

if the mode selected is the reception mode, the device is configured so that a gain of the first and the second analog attenuators are changed towards 1 and 0, respectively, while the position of the intermediate tap is simultaneously changed towards the first end of the variable resistor; and

if the mode selected is the transmission mode, the device is configured so that the gain of the first and second attenuators are changed towards 0 and 1, respectively, while the position of the intermediate tap is simultaneously changed toward the second end of the variable resistor.

40. The device of claim 38 wherein the gain of the first and second attenuators follow a predetermined gain transition curve, wherein the position of the intermediate tap follows a predetermined tap position curve, and wherein the gains and the intermediate tap move incrementally once every predetermined time period.

41. The device of claim 40 wherein the predetermined gain transition curve and the predetermined tap position transition curve both have substantially S-shaped staircase profiles with small gain changes per unit and small tap position changes per unit near the endpoints but large gain changes per unit and large tap position changes per unit in an intermediate range.

42.. The device of claim 38 further comprising:

a correction filter interposed between a second low-pass filter and the second analog attenuator, the correction filter configured to balance the difference in frequency characteristics between a user's voice detected via the user's eardrum vibrations and the user's voice detected via the user's mouth.

43. The device of claim 42 further comprising:

a second A/D converter interposed between the second analog attenuator and the correction filter; and

a first D/A converter interposed between the correction filter and a transmission terminal.

44. A two-way communications device comprising:

a piezoelectric transducer, wherein the piezoelectric transducer is configured to detect vibrations of an eardrum membrane caused by sound waves, and wherein the piezoelectric transducer is also configured to transmit a sound wave to the eardrum membrane;

a housing shaped like an earplug that is configured to contain the piezoelectric transducer; and

an echo-canceller configured to model the variable acoustic characteristics of the eardrum membrane and an ear canal associated with the eardrum membrane.

45. A method for conducting two-way communications using a microphone and an earphone, comprising:

generating ultrasonic waves of a predetermined constant frequency using a first piezoelectric transducer;

directing the ultrasonic waves towards an eardrum membrane;

receiving reflected ultrasonic waves from the eardrum membrane with the first or a second piezoelectric transducer;

analyzing a Doppler-effect modulation of the reflected ultrasonic waves caused by vibration of the eardrum membrane;

demodulating the reflected ultrasonic waves to obtain a voice-transmission signal;

generating a sound wave corresponding to a voice-reception signal; and

superimposing the sound wave on the ultrasonic waves.